

## CLAIMS

What is claimed is:

- 1           1. A method of selecting a data rate of a multicarrier communication  
2     channel, the method comprising:  
3           calculating signal to noise ratios (SNRs) for subcarriers of the multicarrier  
4     communication channel from channel state information and a transmit power  
5     level;  
6           estimating a throughput for each of a plurality of data rates from the SNRs;  
7     and  
8           selecting one of the data rates based on the estimated throughputs.
- 1           2. The method of claim 1 wherein selecting one of the data rates comprises  
2     selecting a combination of one of a plurality of modulations and one a plurality of  
3     code rates associated with a highest of the estimated throughputs.
- 1           3. The method of claim 2 further comprising predicting packet error ratios  
2     (PERs) from the SNRs for each of the data rates, and  
3           wherein the estimating the throughput comprises estimating a throughput  
4     for each of the data rates from the predicted PERs.
- 1           4. The method of claim 3 wherein predicting the PERs comprises using  
2     SNR performance curves for the plurality of data rates to determine a PER for  
3     each data rate, the SNR performance curves being predetermined and stored in a  
4     memory of a receiving station.
- 1           5. The method of claim 3 wherein the predicting PERs comprises:  
2           after demapping bits of a current packet, calculating a bit-error rate (BER),  
3     based on a modulation of the current packet; and  
4           after decoding the bits of the current packet, determining a PER for each of  
5     the plurality of data rates based on a predetermined BER performance of a  
6     decoder, the calculated BER, and a length of the current packet.

1           6. The method of claim 3 wherein the estimating the throughput comprises  
2     estimating a throughput for each data rate of the plurality by multiplying an  
3     associated one of the data rates by one minus the PER predicted for the associated  
4     data rate.

1           7. The method of claim 2 further comprising generating transmit power  
2     level and data rate instructions for a transmitting station, the transmit power level  
3     and data rate instructions to include the selected modulation and code rate and a  
4     selected transmit power level.

1           8. The method of claim 7 wherein the calculating operation is performed  
2     by a receiving station based on a known transmit power level provided by the  
3     transmitting station in a current packet, the current packet being a request to send  
4     (RTS) packet,  
5         wherein the method further comprises:  
6         determining, by the receiving station, the channel state information from  
7     channel estimates and noise power estimates performed on the RTS packet; and  
8         sending, by the receiving station, the data rate instruction to the  
9     transmitting station in a clear-to-send (CTS) packet, the transmitting station to  
10    responsively transmit at least portions of a data packet to the receiving station in  
11    accordance with the data rate instruction.

1           9. The method of claim 1 wherein the multicarrier communication channel  
2     comprises either a standard-throughput channel or a high-throughput  
3     communication channel, the standard-throughput channel comprising one  
4     subchannel, the high-throughput channel comprising a combination of one or  
5     more subchannels and one or more spatial channels associated with each  
6     subchannel, and  
7         wherein calculating the SNRs comprises calculating SNRs for each  
8     subcarrier of the one or more subchannels and the one or more spatial channels  
9     comprising the multicarrier communication channel from the transmit power level  
10    and the channel state information, and

11            wherein the method further comprises generating a data rate instruction for  
12 a transmitter, the data rate instruction to include a selected modulation and a  
13 selected code rate for the one or more subchannels and the one or more spatial  
14 channels comprising the multicarrier communication channel.

1            10. The method of claim 9 further comprising determining the channel  
2 state information, the channel state information including noise power estimates  
3 and a channel transfer function for each subcarrier of the one or more spatial  
4 channels and the one or more subchannels.

1            11. The method of claim 9 wherein the high-throughput communication  
2 channel comprises one of:  
3            a wideband channel having up to four frequency separated subchannels;  
4            a multiple-input-multiple-output (MIMO) channel comprising a single  
5 subchannel having up to four spatial subchannels; and  
6            a wideband-MIMO channel comprising two or more frequency separated  
7 subchannels, each subchannel having two or more spatial channels.

1            12. The method of claim 11 wherein the wideband channel has a wideband  
2 channel bandwidth of up to 80 MHz and comprises up to four of the subchannels,  
3 wherein the subchannels are non-overlapping orthogonal frequency  
4 division multiplexed channels,  
5 wherein each subchannel has a subchannel bandwidth of approximately  
6 20 MHz and comprises a plurality of orthogonal subcarriers, and  
7 wherein the one or more spatial channels are non-orthogonal channels  
8 associated with one of the subchannels.

1            13. The method of claim 9 wherein when the multicarrier communication  
2 channel is a high-throughput communication channel, the one or more spatial  
3 channels and the one or more subchannels are provided by a corresponding one or  
4 more transmit antennas of a transmitting station.

1           14. The method of claim 9 wherein the subcarriers of an associated  
2 subchannel have a null at substantially a center frequency of the other subcarriers  
3 to achieve substantial orthogonality between the subcarriers of the associated  
4 subchannel.

1           15. The method of claim 2 wherein the plurality of modulations comprise  
2 binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 8PSK,  
3 16-quadrature amplitude modulation (16-QAM), 32-QAM, 64-QAM, 128-QAM,  
4 and 256-QAM, and  
5           wherein the plurality of code rates comprise forward error correction  
6 (FEC) code rates of  $\frac{1}{2}$ ,  $\frac{2}{3}$ , and  $\frac{3}{4}$ .

1           16. The method of claim 1 wherein the data rate is further selected based  
2 on a mean-variance adaptation that includes a mean channel power gain based on  
3 channel gains for each of the subcarriers, a variance of the mean channel power  
4 gain, and predicted SNRs for each of the data rates.

1           17. The method of claim 1 wherein estimating the throughput comprises  
2 selecting various data rates for each of the subcarriers of the multicarrier  
3 communication channel based on the SNR for the associated subcarrier, and  
4           wherein estimating the throughput comprises calculating throughputs for  
5 the multicarrier communication channel for the various data rates,  
6           wherein selecting comprises selecting a single data rate for the subcarriers  
7 of one or more spatial channels and one or more subchannels of the multicarrier  
8 communication channel.

1           18. The method of claim 1 further comprising:  
2           after calculating the SNRs for each subcarrier of the multicarrier  
3 communication channel, calculating a subcarrier capacity for each of the data rates  
4 based on the SNR calculated for an associated one of the subcarriers; and  
5           refraining from estimating the throughput for each of the data rates, and  
6           wherein selecting the data rate comprises selecting one of the data rates of  
7 the plurality based on a sum of the subcarrier capacities.

1           19. The method of claim 18 wherein the subcarrier capacity for each  
2   subcarrier is substantially calculated by multiplying a subcarrier frequency spacing  
3   by a logarithm of one plus the SNR for the associated subcarrier divided by a  
4   predetermined subcarrier SNR gap.

1           20. The method of claim 18 wherein selecting the data rate comprises:  
2           determining an upper and a lower data rate based on the sum of the  
3   subcarrier capabilities;  
4           calculating a first number of subcarriers with capacities higher than the  
5   upper data rate;  
6           calculating a second number of subcarriers with capacities lower than the  
7   lower data rate; and  
8           selecting the upper data rate when a difference between the first and  
9   second numbers is greater than a predetermined percentage of the subcarriers  
10   comprising the multicarrier communication channel.

1           21. A communication station comprising:  
2           channel state information processing circuitry to calculate signal to noise  
3 ratios (SNRs) for subcarriers of the multicarrier communication channel from a  
4 transmit power level and channel state information; and  
5           data rate selection circuitry to estimate a throughput for each of a plurality  
6 of data rates from the SNRs,  
7           wherein the data rate selection circuitry selects one of the data rates based  
8 on the estimated throughputs.

1           22. The communication station of claim 21 wherein the data rate selection  
2 circuitry selects one of the data rates from a combination of one of a plurality of  
3 modulations and one a plurality of code rates associated with a highest of the  
4 estimated throughputs.

1           23. The communication station of claim 22 wherein the data rate selection  
2 circuitry further predicts packet error ratios (PERs) from the SNRs for each of the  
3 data rates and estimates the throughput comprises estimating a throughput for each  
4 of the data rates from the predicted PERs.

1           24. The communication station of claim 23 wherein the data rate selection  
2 circuitry predicts PERs comprises using SNR performance curves for the plurality  
3 of data rates to determine a PER for each data rate, the SNR performance curves  
4 being predetermined and stored in a memory of a receiving station.

1           25. The communication station of claim 23 wherein the data rate selection  
2 circuitry calculates a bit-error rate (BER), based on a known modulation of the  
3 current packet, and determines a PER for each of the plurality of data rates based  
4 on a predetermined BER performance of a decoder, the calculated BER, and a  
5 length of the current packet.

1           26. The communication station of claim 23 wherein the data rate selection  
2 circuitry estimates a throughput for each data rate of the plurality by multiplying

3 an associated one of the data rates by one minus the PER predicted for the  
4 associated data rate.

1 27. The communication station of claim 22 wherein the data rate selection  
2 circuitry generates transmit power level and data rate instructions for a  
3 transmitting station, the transmit power level and data rate instructions to include  
4 the selected modulation and code rate and a selected transmit power level.

1 28. The communication station of claim 27 wherein the channel state  
2 information processing circuitry and the data rate selection circuitry are part of a  
3 receiving station, and wherein the data rate selection circuitry calculates the SNRs  
4 based on a known transmit power level provided by the transmitting station in a  
5 current packet, the current packet being a request to send (RTS) packet,  
6 wherein the channel state information processing circuitry determines the  
7 channel state information from channel estimates and noise power estimates  
8 performed on the RTS packet, and  
9 wherein transmitter circuitry of the receiving station sends the data rate  
10 instruction to the transmitting station in a clear-to-send (CTS) packet, the  
11 transmitting station to responsively transmit at least portions of a data packet to  
12 the receiving station in accordance with the data rate instruction.

1 29. The communication station of claim 21 wherein the multicarrier  
2 communication channel comprises either a standard-throughput channel or a high-  
3 throughput communication channel, the standard-throughput channel comprising  
4 one subchannel, the high-throughput channel comprising a combination of one or  
5 more subchannels and one or more spatial channels associated with each  
6 subchannel, and  
7 wherein calculating the SNRs comprises calculating SNRs for each  
8 subcarrier of the one or more subchannels and the one or more spatial channels  
9 comprising the multicarrier communication channel from the transmit power level  
10 and the channel state information, and  
11 wherein the communication station further comprises generating a data  
12 rate instruction for a transmitter, the data rate instruction to include a selected

13 modulation and a selected code rate for the one or more subchannels and the one  
14 or more spatial channels comprising the multicarrier communication channel.

1 30. The communication station of claim 29 where the channel state  
2 information processing circuitry further determines the channel state information,  
3 the channel state information including noise power estimates and a channel  
4 transfer function for each subcarrier of the one or more spatial channels and the  
5 one or more subchannels.

1 31. The communication station of claim 29 wherein the high-throughput  
2 communication channel comprises one of a wideband channel having up to four  
3 frequency separated subchannels, a multiple-input-multiple-output (MIMO)  
4 channel comprising a single subchannel having up to four spatial subchannels, and  
5 a wideband-MIMO channel comprising two or more frequency separated  
6 subchannels, each subchannel having two or more spatial channels.

1 32. The communication station of claim 31 wherein the wideband channel  
2 has a bandwidth of up to 80 MHz and comprises up to four of the subchannels,  
3 wherein the subchannels are orthogonal frequency division multiplexed  
4 channels,  
5 wherein each subchannel has a subchannel bandwidth of approximately  
6 20 MHz and comprises a plurality of orthogonal subcarriers, and  
7 wherein the one or more spatial channels are non-orthogonal channels  
8 associated with one of the subchannels.

1 33. The communication station of claim 29 further comprising one or more  
2 antennas to communicate over the one or more spatial channels and the one or  
3 more subchannels when the multicarrier communication channel is a high-  
4 throughput communication channel.

1 34. The communication station of claim 29 wherein the subcarriers of an  
2 associated subchannel have a null at substantially a center frequency of the other



3 subcarriers to achieve substantial orthogonality between the subcarriers of the  
4 associated subchannel.

1 35. The communication station of claim 22 wherein the plurality of  
2 modulations comprise binary phase shift keying (BPSK), quadrature phase shift  
3 keying (QPSK), 8PSK, 16-quadrature amplitude modulation (16-QAM), 32-  
4 QAM, 64-QAM, 128-QAM, and 256-QAM, and  
5 wherein the plurality of code rates comprise forward error correction  
6 (FEC) code rates of  $\frac{1}{2}$ ,  $\frac{2}{3}$ , and  $\frac{3}{4}$ .

1 36. The communication station of claim 21 wherein the data rate selection  
2 circuitry further selects the data rate based on a mean-variance adaptation that  
3 includes a mean channel power gain based on channel gains for each of the  
4 subcarriers, a variance of the mean channel power gain, and predicted SNRs for  
5 each of the data rates.  
6

1 37. The communication station of claim 21 wherein the data rate selection  
2 circuitry selects various data rates for each of the subcarriers of the multicarrier  
3 communication channel based on the SNR for the associated subcarrier, and  
4 calculates throughputs for the multicarrier communication channel for the various  
5 data rates,  
6 the data rate selection circuitry further selects a single data rate for the  
7 subcarriers of one or more spatial channels and one or more subchannels of the  
8 multicarrier communication channel.

1 38. The communication station of claim 21 wherein the data rate selection  
2 circuitry calculates a subcarrier capacity for each of the data rates based on the  
3 SNR calculated for an associated one of the subcarriers for each subcarrier of the  
4 multicarrier communication channel,  
5 the data rate selection circuitry refrains from estimating the throughput for  
6 each of the data rates, and

7           the data rate selection circuitry selects one of the data rates of the plurality  
8   based on a sum of the subcarrier capacities.

1           39. The communication station of claim 38 wherein the data rate selection  
2   circuitry calculates the subcarrier capacity for each subcarrier substantially by  
3   multiplying a subcarrier frequency spacing by a logarithm of one plus the SNR for  
4   the associated subcarrier divided by a predetermined subcarrier SNR gap.

1           40. The communication station of claim 38 wherein the data rate selection  
2   circuitry:

3           determines an upper and a lower data rate based on the sum of the  
4   subcarrier capabilities;

5           calculates a first number of subcarriers with capacities higher than the  
6   upper data rate;

7           calculates a second number of subcarriers with capacities lower than the  
8   lower data rate; and

9           selects the upper data rate when a difference between the first and second  
10   numbers is greater than a predetermined percentage of the subcarriers comprising  
11   the multicarrier communication channel.

1           41. A system comprising:  
2           a substantially omnidirectional antenna;  
3           a receiver to receive signals through then antenna through a multicarrier  
4           communication channel;  
5           channel state information processing circuitry to calculate signal to noise  
6           ratios (SNRs) for subcarriers of the multicarrier communication channel from a  
7           transmit power level and channel state information; and  
8           data rate selection circuitry to estimate a throughput for each of a plurality  
9           of data rates from the SNRs and select one of the data rates based on the estimated  
10          throughputs.

1           42. The system of claim 41 wherein the data rate selection circuitry selects  
2           one of the data rates from a combination of one of a plurality of modulations and  
3           one a plurality of code rates associated with a highest of the estimated  
4           throughputs.

1           43. The system of claim 42 wherein the data rate selection circuitry further  
2           predicts packet error ratios (PERs) from the SNRs for each of the data rates and  
3           estimates the throughput comprises estimating a throughput for each of the data  
4           rates from the predicted PERs.

1           44. A machine-readable medium that provides instructions, which when  
2           executed by one or more processors, cause the processors to perform operations  
3           comprising:  
4           calculating signal to noise ratios (SNRs) for subcarriers of an orthogonal  
5           frequency division multiplexed communication channel from a transmit power  
6           level and channel state information;  
7           estimating a throughput for each of a plurality of data rates from the SNRs;  
8           and  
9           selecting one of the data rates based on the estimated throughputs.

1           45. The machine-readable medium of claim 44 wherein the instructions,  
2   when further executed by one or more of the processors cause the processors to  
3   perform operations further comprising selecting one of the data rates based on  
4   selecting a combination of one of a plurality of modulations and one a plurality of  
5   code rates associated with a highest of the estimated throughputs.

1           46. The machine-readable medium of claim 45 wherein the instructions,  
2   when further executed by one or more of the processors cause the processors to  
3   perform operations further comprising predicting packet error ratios (PERs) from  
4   the SNRs for each of the data rates, and  
5           wherein estimating the throughput comprises estimating a throughput for  
6   each of the data rates from the predicted PERs.